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INDICATORS FOR INTERNATIONAL COMPARISON OF

MILITARY-TECHNICAL INNOVATION

by

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Contents

Preface

At the end of our century we are witnesses to unprecedented rates of change in all aspects of American life, politics, and world outlook. Change, progress, innovation, and revolution have been best selling themes in our time, and always postulated as the path to a brighter future, for business, for country, and for all mankind. It is tempting to believe the futurists who say this is the dawn of an epoch, of a fundamentally advanced civilization, and furthermore, that we in the United States are leading this revolution. American social culture, our economy, our politics, and our industry are all engaged with new technologies, and they are the archetype for the New World. Technological innovation is changing the globe and its impact on all aspects of society needs to be understood.

Technology's effects on security, in the national and supranational sense, are no exception. New machinery is being injected into all aspects of life, work, and thought, including the world's armies. Historians and professional officers have long contested that military advantage can be gained through technological innovation, and that armed conflict is almost invariably decided in favor of the side with newer or better weaponry. Simple possession of a new weapon system or strategy, however, is not generally enough to ensure victory in battle, as the Germans demonstrated in the opening months of World War II. While the British and French allies possessed more armored assets than the Germans, they were decisively defeated confronting the German blitzkrieg, which had

been better prepared with tactical innovation and organizational adaptations to maximize the armored tank's utility in battle.

In the pursuit and study of innovation, however, little work has been done to empirically measure it. It has been extensively evaluated in descriptive case analyses, as the United States is compared with potential peer competitors like the Soviet Union and China, and as regional balances of power are discussed, such as that between India and Pakistan. Nevertheless an objective, albeit simplified method of rating a country's progress in a certain field (or fields) of innovation would facilitate country studies and comparisons. NATO members have identified a "technology gap" emerging between the U.S. and its allies. They are also concerned about interoperability amongst themselves and primarily with new member candidates. There is growing interest in enhancing modern regional security architectures, such as the WEU or OSCE, or even creating new ones. Insofar as nation-states will remain primary actors in these organizations, and military-technical modernization remains a priority, intelligence organizations along with planning and policy staffs need to evaluate national militaries' modernization with respect to others. This project seeks to facilitate these assessments.

I owe thanks to Lt Col Paul Moscarelli, my faculty research advisor at Air Command and Staff College, especially for his initial guidance in focusing my efforts and his patience in our cooperation. Likewise the library staff at Air University's Fairchild Library were invaluable in organizing a wealth of resources in their first class institution.

Abstract

This project identifies the factors needed to assess a nation's progress in military-technical innovation. Four broad categories of indicators are defined, and then further divided into specific indicators that can be empirically determined for any country's military and for a defined field of military technology. These four dimensions categorize advancements in terms of 1) Technology and hardware itself, including research, manufacturing and procurement capacities, degree of integration with other systems for enhanced or synergistic combat capability, as well as demonstrated performance in tests, exercises, or combat; 2) Operational employment of the new weapon system, to include doctrine and tactics; 3) Organizational innovation to accommodate and optimize the new technology's utility, especially in and by the armed forces, including units created to employ the new system, training established, career progression developed for specialists in the new field of combat arms, plus organizational aspects of the civilian government components of the national security complex, such as governmental policies and strategies incorporating the new type of warfare; 4) Other contextual elements representing the influences on innovation by the country's socio-cultural environment, of which the armed forces are an extension. This last set includes economic factors as well as the influential industry-, media-, and academic "elite" segments of society.

This research derives representative indicators for each dimension of maturity from primarily descriptive case study analyses of alleged revolutions in military affairs in the

United States and other nations. The validity of these indicators are evaluated for how well they represent the concepts of innovation, based on prominent theories of military innovation and on their unbiased applicability to various nations.

Chapter 1

Background

We say therefore War belongs not to the province of Arts and Sciences, but to the province of social life. It is a conflict of great interests which is different from all others. It would be better, instead of comparing it with any Art, to like it to business competition, which is also a conflict of human interests and activities; and it is still more like State policy, which again, on its part, may be looked upon as a kind of business competition on a great scale. Besides, State policy is the womb in which War is developed, in which its outlines lie hidden in a rudimentary state, like the qualities of living creatures in their germs.

—Carl von Clausewitz

This is a study to produce a tool for measuring military-technical innovation in different countries. The study concludes with a set of basic indicator variables selected, defined, and organized to this end. The first section provides an overview of the historical and contemporary context that compels such an endeavor. Next the methodology is presented and then several key conceptual terms are clarified for the purpose of this paper, and to set the stage for the study's theoretical framework, developed in the following chapter.

Introduction to Comparing Military-Technical Innovation

"Victory smiles upon those who anticipate changes in the character of war, not upon those who wait to adapt themselves after the changes occur."[1] This claim, forwarded by one of airpower's bolder and still controversial philosophers, has been reinforced by scholars, leaders, and military observers throughout history, at least as far back as the times of Imperial Rome.

I.B. Holley, among others, shows how this theme has recurred in analyses of organized warfare throughout the ages, but only in our century has it become the generally accepted thesis that new, "superior arms favor victory," or that "a new weapon gave one side an advantage over the other."[2] It is the underlying premise of this study.

Arms superiority has been achieved time and again through weapons development or military-technical innovation (MTI), and nations now pursue innovation as a deliberate defense strategy or goal.[3] Professional and popular literature today is awash with commentary and analysis on the revolutionary changes taking place in the nature of warfare. Although there is agreement that computer and information based technologies have a major role to play in future war, there is less overlap of ideas on just how the evolving strategic environment will affect the conduct of war and on the nature of military threats emerging with new geopolitical arrangements. In fact a grand debate, now decades long, continues in capitals around the globe on how to best incorporate the maxim for technological superiority into defense policy. Issues burn unresolved on how to identify and select technologies (or combinations thereof) with the greatest potential, how much to invest in their development, and how to balance resource demands between innovation and other peacetime, wartime, and other diplomatic endeavors. This challenge demands a deeper understanding of the fundamental nature of national military technical innovation and its relationship with other sociopolitical processes and institutions.

In essence a basic model is needed for innovation, and methods should be developed for its application. Among the issues that warrant consideration is the comparison of nation-states in their readiness, posture and capacity for defense, and therefore the relative merits of their policies and progress in military-technical innovation. Evaluation of scenarios pitting hypothetical combatants against one another has long been the expert occupation of generals,

strategists and governments, but the recent and growing emphasis on the role of innovation in military outcomes has been neglected. Actually a significant effort went into the study of technological innovation and military production for the special case of the Cold War scenario.[4] In pitting the United States against the Soviet Union, this highly developed model and body of literature is now largely inapplicable and the postmodern situation calls for a more general framework, applicable to a variety of players.

As new alliances are forged and international governance expands in myriad manifestations, countries retain primary political roles and are inevitably compared for their ability to meet security challenges inherent in our dynamic world. Hence the abilities of other nations to contribute military security within and beyond their borders has become a most pertinent issue of debate, and their technological capacity to prepare for, deter and defeat perceived threats—in acceptable ways (these constraints are emerging and evolving rapidly too)—vary widely across the international spectrum. Although one key facet of national and supranational security lies in military technical innovation, relatively little has been published on how such innovation could be objectively and empirically measured for comparison with other states. This study endeavors to help fill this void.

Methodology

This project combines several prevalent theories of military technical innovation and revolution to construct a general model for technical innovation, applicable to modern, industrialized countries with significant national armed forces. The research then expands on this baseline template with more specific indicators, of which each represents progress toward military-technical innovation in a nation's armed forces, national security administration, or policy. These indicators are derived from a broad survey of the extant literature on military as

well as bureaucratic, social, political, and technological innovation. Each indicator is analyzed and evaluated for validity as an indicator of innovative progress or potential based on historical case study and/or theory of military-technical innovation and of civil-military relations. This process defines the specific indicators and their collection yields a single comprehensive array of variables to measure a country's progress or maturity in a given field of military technology.

With a rigorous factor analysis, the variables can be empirically weighted and scaled, resulting in a singular innovation index that represents the degree of innovation achieved by the defense forces of a nation-state, especially relative to that reached by other countries measured on the same scale. Such potential consolidation, however, lies beyond the scope of this initial study. Here the indicators are selected and validated to adequately assess all the separate aspects and phases of military-technical innovation.

Concepts and Terminology

The term "innovation" pervades the large body of academic literature concerning military technology and doctrine, and invariably condones revisions to security strategies to meet postmodern demands. With its popularity, the word has inherited additional and broader meaning. In the scope of this study, innovation is meant to include only those new or novel developments that are introduced intentionally and as a result of rational effort. In other words, the study focuses on efforts, policies and programs to innovate military capability, and not on accidental discovery or unintentional changes in capability. Innovation does include however, programs and policies effected as a result of possibly unintended causes or in reaction to unanticipated events.

The question of just what distinguishes "revolutionary" vs. "evolutionary" military-technical innovation is *not* the object of this study. Even though a large proportion of scholarly debate

centers on whether we are in the midst of a revolution in military affairs (RMA) or perhaps witness to several distinct RMAs instead of one, this project avoids that argument. On the other hand, it would seem trite to examine innovation down to the most minor advancements in technology, so the process under scrutiny needs to be delineated. This study will examine the phenomena wherein technological improvements or developments in weaponry (or other military tools), combined with other systems and institutional reforms, yield advantages in combat and in the results of military operations. In such cases where technological innovation can be shown to contribute to achievement of military objectives, operational victory or combat fought more efficiently in terms of casualties or major weapon systems loss, these new ways of fighting will be termed innovation for the purpose of this study. It is not necessary that such innovation result in a fundamentally profound change in the very nature of warfare, as is often cited as prerequisite for a RMA.

Rosen distinguishes "innovation" from "reform," noting that the latter is a result of organizational adjustment or attempted improvement in response to negative feedback in the form of conventional, established measures of performance. The changes then effected by "reform" are to improve effectiveness in performing *established, conventional* missions. This falls short of the drastic or fundamental changes in perspective and mission that comprise true innovation, according to Rosen.[5] While recognizing the greater scope of change, and therefore improvement on a higher order of magnitude sought by Rosen's definition of innovation, the purpose here is to more accurately assess enhanced military capability through any innovation, revolutionary or otherwise.

Notes

[1] Giulio Douhet, *The Command of the Air*, trans. by Dino Ferrari, (Coward-McCann, Inc., New York, 1942; reprinted by Office of Air Force History, Washington, D.C., 1983), 30.

[2] Irving B. Holley, Jr., *Ideas and Weapons*, (New York, Yale University Press, 1953), 3-17.

[3] Lt Col Kathleen M. Conley, "Campaigning for Change – Organizational Processes, Governmental Politics, and the Revolution in Military Affairs," *Airpower Journal* XII, No. 3 (Fall 1998), 54.

[4] See, for example, Matthew Evangelista, Innovation and the Arms Race, (Cornell University Press, Ithaca, 1988), 218-268.

[5] Stephen Peter Rosen, *Winning the Next War*, (Ithaca: Cornell University Press, 1991), 29-35.

Chapter 2

Theoretical Framework

Organizational processes and governmental politics hold the key to military innovation, whether on the eve of battle or at the dawn of a revolution in warfare.

—Kathleen M. Conley, Lt Col, USAF

Core postulates and conclusions from historical analysis and innovation theories are presented in this section, and these then serve as the framework for a model with which to outline innovation indicators. Upon examination of the source literature, four basic dimensions of innovation are proposed for the categories or axes, along which the variables for military-technical innovation can be logically grouped.

Andrew Krepinevich has written extensively on the subject of RMA and is credited with one of the first attempts "by the American defense establishment to define military-technological revolutions."[1] Working for the Office of Net Assessment, he noted that military-technical revolutions in general "are characterized by technological change, military systems evolution, operational innovation and organizational adaptation."[2] Most authors concur with this general framework, emphasizing the fact that technology hardware alone will not guarantee advantage in combat and does not in itself represent a substantive change in the nature of war. More recently, Jeffrey McKitrick and his analyst colleagues at the Science Applications International Corporation (SAIC) focused "on the three dimensions of the RMA required for a nation to achieve competitor status" (in what they perceive as the current RMA in progress in the U.S.).

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These three elements are "a conscious decision on the part of the state to acquire all or portions of what may be termed the RMA complex," the capacity to "acquire or develop" the necessary technologies, and finally the flexibility for their institutions and methods to evolve and exploit the RMA's potential.[3]

In another effort to explain the nature of successful innovation, Dr. Ahmed S. Hashim, expert on Asian military capabilities and defense policies at the Center for Naval Analyses in Washington, D.C., acknowledges a widening "gap" in military RMA capabilities between the nations of the West and the rest of the world. He contends that the capacity to exploit the RMA for military benefit depends on several factors. He cites "technological infrastructure and financial resources" as national level prerequisites to develop the technology, and then "flexibility" in organizational culture, structure, and doctrine within a country's armed forces themselves.[4]

From this brief sampling of work on the RMA, several common themes already emerge. Not surprisingly, the new technology itself is a prerequisite. While much work on the subject of innovation is devoted to identifying which technologies harbor the greatest payoff potential, this study presupposes the field of innovation to be already selected, and all the derived variables are meant to be evaluated with a given technology (or combined system) in mind. Furthermore, beyond simple hardware and know how is a vast supporting network of considerations that make technology useable or useful. Differences among countries in this "technological infrastructure" account for their relative ability to understand, incorporate, and effectively exploit given technologies. Such infrastructure includes research and development facilities and resources, material resources and access to replenishment, as well as that which Hashim calls "technological literacy" in a given society and culture.[5] These related factors, which

Krepinevich termed "technological change and military [hardware] systems,"[6] comprise a "technology" dimension to innovation, hinged on the science and resources to procure and develop the machinery that enables the MTI.

The next logical step in implementing military innovation with new tools or weapons is to develop the methods for their employment. This dimension can be called the "operational" dimension, as it concerns how the technology is integrated with military operations or missions. Many authors in fact tend to think of innovation in terms of new types of operations, enabled at least in part by new technologies. Analysts at SAIC and elsewhere refer to these innovations as "new warfare areas," and point to armored-, aircraft carrier-, and amphibious warfare as twentieth century examples.[7]

"No one has yet explained how nations can wage war under modern conditions without operating with and through the huge bureaucracy that is the American military. The problem of military innovation is necessarily a problem of bureaucratic innovation."[8] In this way S.P. Rosen succinctly identified the third element in the "innovation trinity" as the military organization itself, to include its supporting bureaucracies and professional culture. Dr. Rosen and others adamantly point to bureaucratic resistance to change as the primary impediment to otherwise promising innovation efforts, so measures taken to overcome these obstacles are addressed accordingly in any treatment of modern MTI.[9]

Even with a conscientious effort to innovate, nations meet with mixed success and analysts have suggested a variety of additional extenuating circumstances and causal factors as explanations for varied performance in innovation. Most, if not all, of these elements can be linked to processes or institutions beyond the control span of a nation's armed forces and national security administration, and external to its technology or military doctrine. Therefore

they can be considered elements of a separate fourth dimension, designated "contextual" in this

project, since they fall within a conceptual environment surrounding but also interacting with a

nation's armed forces. Reference to a standardized list of "contextual elements," such as is

presented in U.S. military doctrine, is helpful in the identification of these external forces

significant to MTI.[10] These forces, external to the nation's military purview, can nevertheless be

often seen to wield decisive influence in retarding or promoting military-technical innovation.

Notes

[1] Gwen Story and Sybill Glover, ed., *War Theory Coursebook*,. (Maxwell AFB, AL: Air Command and Staff College, 1998), 34.

[2] Andrew F. Krepinevich, Jr., "The Military-Technical Revolution: A Preliminary Assessment," in *Air Command and Staff College War Theory Coursebook*, ed. Gwen Story and Sybill Glover, (Maxwell AFB, AL: Air Command and Staff College, 1998), 34-35.

[3] McKitrick, Jeffrey, et. al. "The Revolution in Military Affairs," in *Battlefield of the Future – 21st Century Warfare Issues, e*d. Barry R. Schneider, and Lawrence E. Grinter, (Maxwell AFB, Ala.: Air University Press, 1998), 74.

[4] Ahmed S. Hashim, "The Revolution in Military Affairs Outside the West," in *Journal of International Affairs,* Vol. 51, Issue 2 (Spring '98), 431.

[5] Ahmed S. Hashim, "The Revolution in Military Affairs Outside the West," in *Journal of International Affairs,* Vol. 51, Issue 2 (Spring '98), 432.

[6] Andrew F. Krepinevich, Jr., "The Military-Technical Revolution: A Preliminary Assessment," in *Air Command and Staff College War Theory Coursebook*, ed. Gwen Story and Sybill Glover, (Maxwell AFB, AL: Air Command and Staff College, 1998), 34-35.

[7] McKitrick, Jeffrey, et. al. "The Revolution in Military Affairs," in *Battlefield of the Future – 21st Century Warfare Issues, e*d. Barry R. Schneider, and Lawrence E. Grinter, (Maxwell AFB, Ala.: Air University Press, 1998), 75.

[8] Stephen Peter Rosen, *Winning the Next War*, (Ithaca: Cornell University Press, 1991), 2.

[9] See, for example, Lt Col Kathleen M. Conley, "Campaigning for Change – Organizational Processes, Governmental Politics, and the Revolution in Military Affairs," *Airpower Journal* XII, No. 3 (Fall 1998), 54-55; as well as Stephen Peter Rosen, *Winning the Next War*, (Ithaca: Cornell University Press, 1991), 2-3.

[10] Representative are such campaign planning considerations as the Political environment, personal Leadership, Socio-cultural factors and Economics. See Lt Col Larry A. Weaver and Maj Robert D. Pollock, "Campaign Planning for the 21st Century" in *War Theory Coursebook*,. (Maxwell AFB, AL: Air Command and Staff College, 1998), 30-31.

Chapter 3

The Technology Factor

For twenty years, the Air Force was built around pilots, pilots, pilots, and more pilots. The next twenty years is going to be around scientists.

—General Henry H. "Hap" Arnold

Procurement and Production

Possession of Technology

Certain technologies are at the core of decisive military technological innovation, and little to no progress toward military advantage in a given field can be achieved without possession of said hardware and the knowledge to use and manipulate it. Therefore the initial step in innovation is normally traditionally to procure the technology. In today's strategic environment, in which most technology has a dual-use application in both civilian and military markets, and in which national policies are mostly transparent, and commerce is mostly global, nations need not invent new technology to exploit it. However, a state that must purchase technology abroad is arguably less likely to wield it as effectively as the nation that is capable of inventing or manufacturing it, as the latter is usually better equipped to understand and further refine the technology.

Domestic Production vs. Import

Therefore indigenous production capacity represents a greater degree of innovative maturity, beyond possession of the finished product, system and spare parts.[1] There are alternatives to domestic manufacturing, and these need to be rated for efficacy in comparing nations for their relative access to a given technology. Industrial and military espionage to acquire technology undoubtedly continue to augment the open market imports of many countries, and should also be considered in a comprehensive assessment of a nation's innovation potential. How such a requisition scheme can fit into a national innovation strategy is vividly portrayed in case studies of the cold war policies of the USSR, such as described by Matthew Evangelista in *Innovation and the Arms Race*.[2]

Technological Infrastructure

This variable, as mentioned in the previous section, considers the knowledge base and institutional capacity to further refine the technology. It comprises, at least in part, the academic research and/or civilian industrial facilities for scientific and engineering development, advancement, and adaptation in the postulated technological field.[3]

Development

Despite the race to develop new technologies in modern times, and the competitive secrecy that surrounds R&D, the consensus among scholars is that revolutions in military affairs typically occur or mature long after the basic technology is initially demonstrated and even fielded.[4] By this time both sides of a conflict are generally aware of, and have access to the technology. Hence an RMA does not traditionally arise from a truly "secret weapon," but is historically more likely to emerge from the synthesis of young technology newly integrated with other technologies and procedures. Such was the case with the German blitzkrieg into Poland

and France, enabled by Wehrmacht forces drilled in the cooperative employment of aircraft, tanks and radios.[5] Another example from an earlier period is that of the English long bow, which contributed significantly to Edward III's victory at Crecy in 1346, surprising the French even though it had been in use for almost 250 years.[6]

Numerous cases like these amply illustrate that military technical innovation, while requiring a core competency in procuring and developing a technology, is not effected merely by possessing the hardware. Nevertheless, once a promising technology is identified, as envisioned in the application of these indicator variables, the state of the technology's development can allude to a country's progress in innovation. Specific examples of indicators in this category include the degree to which a new technology has been integrated with others, whether there is capacity for full scale or only limited production of the hardware, and the extent to which the new system has been tested and demonstrated. Indeed, an army further along in the process may have prototypes or even regular production models fielded with operational units (although the MTI is not mature if operators are not yet trained and tactics and doctrine remain undeveloped).

Versatility and Durability

It has been shown that innovation, beginning with the introduction of a certain technological application, or perhaps with a requirement envisioned, may then proceed over a relatively long period of years or even centuries before resulting in decisive military outcomes against an opponent. Despite the mantra that technology is being developed and incorporated into all aspects of work and society at an ever-increasing pace, many experts maintain that it still takes time for a military force to learn how to best employ new systems. "We must bear in mind that it took centuries for firearms to move from the periphery of the battlefield to the core. There is a deep chasm between the advent of new technology and its full implementation on the

battlefield."[7] Until the military advantage of an innovation is exploited, it is not clear to military

leaders just how or when a technological edge will yield results in battlespace; outbreak of war is

not reliably predictable far in advance. Scholars of MTI, including Holger Mey at the German

Institute for Strategic Studies, therefore recognize that "the utility of a particular innovation

declines with time," since "every technological innovation eventually provokes a

countermeasure." This leads to the conclusion that "technological innovation always must be

seen in the dynamic context of developing countermeasures. By the same token, new

technologies are always at their best in the brief period before the countermeasures can be

introduced."[8]

It also follows that in general, "a multipurpose application is better than a highly specialized

one,"[9] since it is adaptable to a broader span of possible contingencies. In this context, when

comparing nations in their relative advancements along a certain line of technological

development, a variable can be defined to evaluate the degree to which a nation's application, up

to the stage of a finished, fielded weapon system, is specialized.

Notes

[1] Ahmed S. Hashim, "The Revolution in Military Affairs Outside the West," in *Journal of International Affairs,* Vol. 51, Issue 2 (Spring '98): 431-433.

[2] Matthew Evangelista, *Innovation and the Arms Race*, (Ithaca, New York: Cornell University Press. 1988), 218-268.

[3] Ahmed S. Hashim, "The Revolution in Military Affairs Outside the West," in *Journal of International Affairs,* Vol. 51, Issue 2 (Spring '98): 431-433.

[4] Irving B. Holley, Jr., *Ideas and Weapons*, (New York, Yale University Press, 1953), 4-5.

[5] Andrew F. Krepinevich, Jr., "The Military-Technical Revolution: A Preliminary Assessment," in *Air Command and Staff College War Theory Coursebook*, ed. Gwen Story and Sybill Glover, (Maxwell AFB, AL: Air Command and Staff College, 1998), 45.

[6] Irving B. Holley, Jr., *Ideas and Weapons*, (New York, Yale University Press, 1953), 3-5.

[7] George and Meredith Friedman, *The Future of War – Power, Technology and American World Dominance in the 21st Century*, (New York: Crown Publishers, 1996), xii.

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Notes

[8] Holger H. Mey, "The Revolution in Military Affairs: A German Perspective" in *Comparative Strategy* 17, Issue 3 (Jul-Sep 1998), 314.
[9] Ibid.

Chapter 4

The Operational Factor

The indicators examined on the operational dimension seek to measure how far an army has come in optimizing a new technology's employment means. The military force under consideration may have integrated the stated technology into its operations and have already employed it in combat conditions, or in combat training exercises. Lacking those opportunities for innovation, a preliminary fielding of the weapon system could be found in a test environment. Besides actually fielding and employing the hardware, documented studies, policies and directives can provide a measure of the technology's operational maturity in conceptual terms. Following this line of reasoning, two broad subcategories of indicators emerge to encompass conceptual and procedural guidance provided for employment of the technology, and then various types of practical employment of the technical innovation.

Guidance

Operational and Tactical Doctrine

Whether or not a nation possesses a new technology it prepares for its purchase, development and anticipated usage and the military will evidence this preparation in plans for integration of the technology. Therefore the development and distribution of operational and tactical doctrine, published by an authoritative source in government or the military, represents a

step in innovation and indicates advancement on the innovation scale. Exposure to the technology in an official combined training forum, in a sense just "borrowing the technology to try it out," can also represent a rudimentary beginning in the formulation of intent and preparation for a new technology. More advanced knowledge in the form of published or updated operational level doctrine that covers employment of the new system represents another stage in a maturing innovation. This progress could also be assessed based on tactics, techniques and procedures (TTP) that are published, distributed and used in operational units.[1]

An integral consideration in the development of an innovative "war form" is the need to define measures for effectiveness, which may seem very different from traditional standards.[2] Innovation is often preceded by a debate on what constitutes military success or effectiveness, and armed forces take varying amounts of time in establishing consensus on the issue. Changes in the strategic environment, or in the prevalent nature of armed conflicts will lead to such a debate, as experts argue whether or not the observed changes are temporary or long-term. In any case, the conduct of such a debate, in the government, among the services themselves, in academia, the media and in professional literature is a step toward innovation. Once the new measure of effectiveness, of success, or of victory is established, as evidenced by acceptance in policy, strategy and doctrine, another hurdle in innovation is crossed.

Training

Once doctrine is developed for the MTI, it must be promulgated within the force. This is accomplished by a variety of mechanisms, including training programs or even dedicated schools, whose programs and performance can therefore serve as empirical indicators along the innovation progression. Entirely new training institutions may be warranted, depending, in part,

on how broadly the field of MTI is defined (e.g., "aerial strategic bombardment" or "information warfare"), or training programs may be added to existing school curricula.

To inculcate more senior troops and established organizations with guidance in applying innovative technology also requires that it be exercised, presuming the nation "lacks" an ongoing conflict in which to practice the new methods. Accordingly, observation of doctrine applied in the conduct of military or defense exercises can serve as an indicator of innovation, or a step along a graduated scale of maturity in MTI.

Employment

Operations

When a candidate technology for MTI is fielded and employed by military forces in actual operations, then yields historically high enemy losses compared with historically low friendly casualties, all while contributing to the successful accomplishment of operational campaign objectives, then this system or combination of technologies has by definition matured as a form of innovation. The possibility remains that the armed forces will mature still further yet with this technology, but for purposes of this study, such a victory achieved by new weaponry employed using novel TTP and instituted by a force redesigned to exploit it, constitutes the innovation sought. Thus such actual experience for an army must count as a full scale or heavily weighted factor in quantifying its innovation maturity.

Experience in applying MTI can take forms other than full-scale war. The force that employs similarly new technology, tactics, and organization in operations short of war, and achieves operational objectives with acceptable losses, can be considered effective and innovative. As has been shown, far-reaching innovation involves new perspectives on what

constitutes success, and in Military Operations Other Than War (MOOTW) success is most often determined by parameters other than casualty ratios and victorious battle. Non-lethal weapons offer an illustrative example of an emerging innovation, with standards of effectiveness fundamentally different from those of traditional combat weaponry. Any type of military mobilization, deployment and engagement can yield evidence of military technical innovation, although consideration must then also be given to an evaluation of the forces' performance and the operation's outcome, as either successful or failed.

Readiness

Short of employment against an opposing force, other indications of MTI are presented by the formation of operational units organized, trained, and equipped with the new system(s), even with limited experience. Therefore a nation whose armed forces field the innovative technology, but which have not yet tested it in actual contingencies, have achieved an intermediate level of operational innovation. This variable can be further broken down into intermediate variables corresponding to readiness ratings of forces equipped with the MTI systems and missions, such as training completion rates or exercise frequency.

Notes

[1] Ahmed S. Hashim, "The Revolution in Military Affairs Outside the West," in *Journal of International Affairs,* Vol. 51, Issue 2 (Spring '98): 431.

[2] Stephen Peter Rosen, *Winning the Next War*, (Ithaca: Cornell University Press, 1991), 20,24.

Chapter 5

The Organizational Factor

The major limits on exploiting long-available technologies are not inadequate research and development and procurement, but rigid and parochial organizational systems within and among the military services.

—William E. Odom

In no profession is the dread of innovation so great as in the army.

—Col John Mitchell, British Army
Thoughts on Tactics and Military Organization

Military-technical innovation is inextricably intertwined in the bureaucratic processes that run a nation and its armed forces. Various aspects of organizational culture, structure and composition can either facilitate military-technical innovation or retard it, and this may also depend on the specific technologies under consideration. This section focuses on how the nation's military establishment—that is its armed forces and the agencies that govern and augment them for the sake of military security—influence its own innovation.

Eight indicators in the area of organizational factors can be derived from and supported by innovation theory, military-historical analysis, and current observations of militaries seeking to enact a RMA. These lend themselves to three subdivisions, roughly corresponding to the hierarchical elements of any organization: the military's leadership and mission (or "charter"), its bureaucratic or force structure, and its membership, i.e., the officer corps and soldiers in arms. These three sets of indicators are examined in more detail below.

Leadership and Mission

National Goals and Strategy

In order for a bureaucratic organization to pursue the acquisitions and reorganization inherent in innovation, it must logically organize and direct the innumerable sub-tasks involved in such an endeavor. National governments and militaries acknowledge their intent to innovate and articulate this goal and the supporting rationale in some form of proclamation, which serves as an indicator for national military-technical innovation. The plan to innovate is normally expressed in an official document under the auspices of national military strategy and or a vision statement, such as *the United States' Joint Vision 2010*, which cites "technological innovations" as a key enabler for future warfighting.[1]

Instead of outright proclamation, a nation can also signal its desire for MTI by commissioning formal self-evaluation to prescribe a strategy for transformation. Kathleen Conley cites the official studies done for the Quadrennial Defense Review (QDR) and the National Defense Panel (NDP) as indicators to "predict the success" of the RMA in the U.S., and shows how these processes reflect deliberate decision making processes leading to the goal of innovation.[2] She examines these investigations and their respective conclusions in the context of the "rational actor model" for government decision making, which she borrowed from Graham Allison's *Essence of Decision*. While noting that the QDR and NDP both "relied upon rationally based analyses which led each to recommend that the US military transform itself," each advocates a different strategy. Of key value in this process, however, is that they both can "furnish the Department of Defense (DOD) with a clear vision that can unite disparate organizations."[3]

Clearly an affirmation of commitment to innovation, whether decreed in a plan or explored via self-study, is an indicator of innovation either in progress or on the verge of commencement. With this variable, consideration should also be given to the degree of acceptance evident for the proclamation. This could be measured with a more thorough examination of the nation's parliamentary procedures for ratifying such documents, vote counts, commentary in the media and/or opinion polls. It is not enough to simply publish a document at higher headquarters level if it is not sanctioned by the organization as a whole. The strategy also needs to be congruent. Contradictory strategies reveal unrealistic goals or insincere policy. For example, a strategy for military-technical innovation must be supported with recognition of a changed strategic situation. A policy that emphasizes the need to acquire more conventional arms or upgrade the standing forces is inconsistent with priority on innovation, which typically emphasizes research and development or experimentation.

Visionary Leader and Champion for Innovation

Ultimately the power to innovate, at least in peacetime, according to Rosen, resides with senior leadership. Respected representatives from this level of hierarchy must convey a "strategy for innovation, which has both intellectual and organizational components," such as creating new promotion tracks for officers specializing in an innovative branch. This is the essential ingredient for innovation in peacetime, and because the bureaucracy will resist such an endeavor, it may be instrumental to provide such reform-minded leadership with support from influential civilian outsiders.[4]

Successful innovation also requires an effective strategy for coping with uncertainty.[5] This demands a vision or general idea of the future nature of warfare, or of the strategic environment in which military forces will be employed. Rarely are these predictions clear and foreordained,

so to unify a nation and its defense establishment on such a controvertible course of action takes a strong and prominent leader. He or she must be capable of framing the vision, justifying the call for innovation and gaining support for the effort. Rosen sees the leader's challenge as nothing less than an "ideological struggle that redefines the values that legitimate the activities" of the military. This struggle must entail a new "theory of victory," plus an easily understandable "explanation of what the next war will look like" and how it can be won.[6]

In seeking out leadership, one must look for more than just a popular and visionary personage, but also one who is empowered with the authority to harness the necessary resources and to legitimize changes in established procedures. For the innovation to succeed, "an authoritative leader, whether it be the JCS chairman or some other official, must champion its implementation."[7] McKitrick and others[8] echo these sentiments: "to be successful and lasting, the change must come from the top—from leadership. The impetus for change must flow throughout the entire organization, especially through the education system. The required changes cannot occur without the support and encouragement of leadership."[9]

Force Structure and Bureaucratic Organization

Elements Charged with Innovation Programs

In addition to using the rational actor model, Kathleen Conley also analyzes America's prospects for a revolution in military affairs by comparing insights offered by two other organizational models.[10] These are the organizational process and governmental politics frameworks, which "provide the analyst with greater explanatory and predictive power" regarding the RMA.[11] Whereas the first model "treated governmental action as the result of rational choice," these two emphasize the multiple channels of communication and control

between organizations and sub-units, and then the competition among organizations and elements to increase their own power, respectively. They imply that one technique to support MTI is to create a (sub-) organization with innovation as its mandate and reason for existence. Hence identification of such an element in national military hierarchies serves as another indicator of innovation or its enhanced potential.

Examples abound in Western militaries and Ministries of Defense. "Battlelabs" and the Joint Warfighting Center under Atlantic Command in the US were created and empowered to foster military-technological innovation. Such "innovation" cells can also facilitate integration of technologies and new methods into routine operations, such as J-39 at the US Joint Chiefs of Staff, which is tasked to incorporate the new "area of warfare"—Information Operations—into American war plans. Another interesting example in more planned economies are the "science cities" *(Naukogrady)* found in Russia and which had been relatively productive in Soviet times. Entire cities built to research designated technologies and scientific sectors, and dedicated to military goals, they now are in peril, according to RAND's Sharon Leiter, along with the rest of Russia and her military-industrial complex, as victims of macroeconomic crisis. Nevertheless, some claim they represent one of Russia's best hopes for revival in civilian or dual-use scientific modernization, as directors try (so far in vain) to "transform them from graveyards to incubators of advanced technologies."[12]

Programs and Procedures for Innovation

The people charged with the innovation mission must also be equipped with guidelines and procedures sanctioned by the bureaucracy, in order to carry out their tasks in promoting innovation. Therefore in assessing MTI, the country's military establishment should be evaluated for the amount and quality of programs instituted to effect innovation. The United

States' Advanced Technology Demonstrations (ATD), Advanced Concept Technology Demonstrations, (ACTD) and Joint Warfighting Experiments (JWE) as described in the DOD's Joint Warfighting Science and Technology Plan serve as examples of programs designed to "ensure the transition of innovative concepts and superior technology to the warfighter and acquisition customer both faster and less expensively than the traditional means."[13]

High fidelity modeling and simulation is also viewed as a solution to the problem of evaluating potential technologies in a multitude of possible, but uncertain future scenarios. They represent some of the best tools available in preparing for an uncertain future, but are themselves based to varying degrees on past experiences and statistically demonstrated performance of legacy systems, policies, and practices.[14] As Conley points out in the case of the Deep Attack Weapons Mix Study, such simulation tools can also lead to misleading conclusions regarding the potential of innovation, to the degree that they model warfare with a pre-existing paradigm, which could be rendered obsolete by the very innovation in question.[15]

Finally, in addition to overt support for innovation, either in general or for specific systems with an organization and programs designated to oversee progress, some bureaucratic obstacles can be avoided with secrecy. Classification can cloak a program from excessive critical scrutiny, such as the USAF managed development of the F-117 stealth attack jet.[16]

Resources for Innovation

Defense budgets are among the most accurate barometers of defense policies and prioritization, and consequently they should be factored into any assessment of a nation's defense programs, including innovation. However, what is budgeted for certain programs may not accurately reflect final resource allocation. For example, a recent RAND study on Russian military research and development, the seedbed for military-technical innovation, confirms that

despite strong support in the Russian Ministry of Defense and legislated priority, "the appropriated funds [for military R&D] are not reaching their destinations." Instead it is diverted to more urgent crises and requirements, such as to calm social unrest due to unpaid salaries, to support troops in conflicts and peacekeeping missions, and to repay growing debts from past years. [17]

This variable also requires an examination of the budgeting process itself, since some procedures may be inherently more responsive to changes (e.g., with shorter intervals between new requirements inputs) or innately more amenable to innovation, based on linkages to other organizations' inputs and priorities. In her essay critiquing America's capacity to pursue the current RMA, Lt Col Conley points out that our Planning, Programming and Budgeting System "is inherently limited when it comes to implementing innovations such as the RMA." Like many bureaucracies, it inherently favors funding existing systems over "RMA technologies."[18]

Force Structure

The manner in which armies are manned, mobilized, and organized can have an impact on their ability to innovate, and may also be affected by adaptations to incorporate innovations in the organization. Some countries, especially smaller states, maintain only a single army under one chief of staff. Nations with multiple service branches, in comparison, can either facilitate innovation by generating multiple alternatives in development of technological solutions, or they may hinder MTI with parochial infighting between services, such as for roles and missions, or simply for budget funds.

Hashim discusses several aspects of what appears to be a new model military, based on a Western prototype, which he attests is better adapted to exploit the RMA in high technology. As European nations move toward all volunteer or partially professionally armed forces, Hashim

asserts that such professional forces should normally be more adept at exploiting the potential of advanced technology systems than an all conscript force. The size of the force becomes a factor in training and standardization, with larger forces costing more in time and materiel to refit with new equipment and then to retrain.[19] Of course, the term of conscription will also affect the trainability of an army. All these characteristics should be included in an assessment of a force's potential or progress in MTI.

Force Composition

Officers in Specialty

As the case was made for naval officers in submarine warfare and then army officers in helicopter aviation, these new "warfare areas" were assured sponsors when talented young officers could be attracted to the field by successful mentor role models and the prospects for promotion were established.[20] These and other illustrative innovations justify an indicator seeking the establishment of an officer cadre in the field of innovation, and with a defined and endorsed career progression. Andrew Krepinevich cited this need as paramount, after leadership, to successful organizational innovation. He wrote that innovation is institutionalized "primarily by attracting talented young officers to the cause. However, these officers are unlikely to risk their careers supporting innovation unless their mentors are able to protect and promote them. The redirection of human resources appears to be the crucial element in effecting peacetime military innovation."[21]

Contingency Support Groups

Interest groups evolve naturally within any large bureaucracy, and in the military, various cadres can rally around weapon systems. These groups may extend beyond the officer career

field and the organizational elements tasked directly to support innovation in a certain area.

Conley uses the examples of "platform" prejudice in describing how the governmental politics

model applies to American implementation of a RMA.

> Often, existing action channels tended to incorporate the technologies into certain platforms, whether or not it was the best way to exploit the technology. Each platform—aircraft carrier, fighter aircraft, and main battle tank—had a community that had grown up around it and sought to enhance that platform's capability. The services became committed to those platforms, which were seen as central to each service's ethos. The platforms also developed constituencies in Congress, whose members saw the continued production of the platforms as ensuring jobs in their states or districts. Therefore, the surest channel for fielding RMA technologies is to build them into and around carriers, manned aircraft, and heavy armor. The difficulty is that this approach is unlikely either to produce the most defense capability or to engender rapid adoption of RMA technologies.[22]

Notes

[1] *Air Force Doctrine Document (AFDD) 1, Air Force Basic Doctrine*, (HQ AFDC/DR, 1997), 36-37.

[2] Lt Col Kathleen M. Conley, "Campaigning for Change – Organizational Processes, Governmental Politics, and the Revolution in Military Affairs," *Airpower Journal* XII, No. 3 (Fall 1998), 56, 62-63.

[3] Lt Col Kathleen M. Conley, "Campaigning for Change – Organizational Processes, Governmental Politics, and the Revolution in Military Affairs," *Airpower Journal* XII, No. 3 (Fall 1998), 62-64.

[4] Stephen Peter Rosen, *Winning the Next War*, (Ithaca: Cornell University Press, 1991), 20-21.

[5] McKitrick, Jeffrey, et. al. "The Revolution in Military Affairs," in *Battlefield of the Future – 21ˢᵗ Century Warfare Issues, e*d. Barry R. Schneider, and Lawrence E. Grinter, (Maxwell AFB, Ala.: Air University Press, 1998), 96; Stephen Peter Rosen, *Winning the Next War*, (Ithaca: Cornell University Press, 1991), 243-249.

[6] Stephen Peter Rosen, *Winning the Next War*, (Ithaca: Cornell University Press, 1991), 20.

[7] Lt Col Kathleen M. Conley, "Campaigning for Change – Organizational Processes, Governmental Politics, and the Revolution in Military Affairs," *Airpower Journal* XII, No. 3 (Fall 1998), 69.

[8] See comments, for example, by Lt Col Frank G. Hoffman, "Innovation Can Be Messy" in *U.S. Naval Institute Proceedings* 124, No. 1 (Jan 1998), 48.

[9] McKitrick, Jeffrey, et. al. "The Revolution in Military Affairs," in *Battlefield of the Future – 21ˢᵗ Century Warfare Issues, e*d. Barry R. Schneider, and Lawrence E. Grinter, (Maxwell AFB, Ala.: Air University Press, 1998), 96.

[10] Conley considers the RMA to consist of the combined innovations to exploit "precision weaponry, stealth and information technology;" Lt Col Kathleen M. Conley, "Campaigning for

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Change – Organizational Processes, Governmental Politics, and the Revolution in Military Affairs," *Airpower Journal* XII, No. 3 (Fall 1998), 69.

[11] Lt Col Kathleen M. Conley, "Campaigning for Change – Organizational Processes, Governmental Politics, and the Revolution in Military Affairs," *Airpower Journal* XII, No. 3 (Fall 1998), 56.

[12] Leiter, Sharon, *Prospects for Russian Military R & D (*Santa Monica, CA: RAND, 1996), 16.

[13] *Joint Warfighting Science and Technology Plan, (*Dept. of Defense. Director, Defense Research and Engineering, 1998), III-1. Also see Lt Col Kathleen M. Conley, "Campaigning for Change – Organizational Processes, Governmental Politics, and the Revolution in Military Affairs," *Airpower Journal* XII, No. 3 (Fall 1998), 65

[14] See, for example, one landmark work in this field by Trevor N. Dupuy, *Numbers, Predictions & War*, (Fairfax, Virginia: Hero Books, 1985), 3-18.

[15] Lt Col Kathleen M. Conley, "Campaigning for Change – Organizational Processes, Governmental Politics, and the Revolution in Military Affairs," *Airpower Journal* XII, No. 3 (Fall 1998), 65.

[16] Lt Col Kathleen M. Conley, "Campaigning for Change – Organizational Processes, Governmental Politics, and the Revolution in Military Affairs," *Airpower Journal* XII, No. 3 (Fall 1998), 67.

[17] Leiter, Sharon, *Prospects for Russian Military R & D,* (Santa Monica, CA: RAND, 1996), x.

[18] Lt Col Kathleen M. Conley, "Campaigning for Change – Organizational Processes, Governmental Politics, and the Revolution in Military Affairs," *Airpower Journal* XII, No. 3 (Fall 1998), 65.

[19] Ahmed S. Hashim, "The Revolution in Military Affairs Outside the West," in *Journal of International Affairs,* Vol. 51, Issue 2 (Spring '98), 431.

[20] See especially Rosen's chapters on "Making Things Happen: The Politics of Peacetime Innovation" and "New Blood for the Submarine Force" in *Winning the Next War*, (Ithaca: Cornell University Press, 1991), 85-105,130-147.

[21] Andrew F. Krepinevich, Jr., "The Military-Technical Revolution: A Preliminary Assessment," in *Air Command and Staff College War Theory Coursebook*, ed. Gwen Story and Sybill Glover, (Maxwell AFB, AL: Air Command and Staff College, 1998), 58.

[22] Lt Col Kathleen M. Conley, "Campaigning for Change – Organizational Processes, Governmental Politics, and the Revolution in Military Affairs," *Airpower Journal* XII, No. 3 (Fall 1998), 67.

Chapter 6

Contextual Elements

There is nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things. For the reformer has enemies in all those who profit by the old order, and only lukewarm defenders in all those who would profit by the new order...[because of] the incredulity of mankind, who do not truly believe in anything new until they have had actual experience of it.[1]

—Niccolo Machiavelli
The Prince

Societal Context

The success of a military force in innovation, as in battle, is also subject to external influences in the civilian environment, primarily from the society whence it draws its human, material and moral resources. There are certain elements of civilian society, which play significant roles in developing technology for the armed forces and supporting the military and entire national defense organization in advancing national security. Citing innovation in British air defense and U.S. Army helicopter aviation, along with works by Kurt Lang and Barry Posen, S.P. Rosen discusses various scenarios in which civilian intervention has led or catalyzed military innovation.[2] He writes "peacetime and technological innovations in the American military have in practice been more closely linked to analyses of the anticipated security environment, which is determined by economic, technological, and political factors largely outside the control of either the United States or its potential adversaries."[3]

The most influential segments of society, by definition called "elites" in political science, include prominent groups, even outside government, that influence technological development and procurement for the military. These include industry (private corporations), the media, and academia, and the nature and activities of these groups accordingly serve as indicators in assessing the national opportunities and progress in innovation. Additionally, the general public's relationship with the armed forces and their bureaucratic representation represent a variable of "civil-military relations," which also may have a variable impact on the ability of an innovation to progress in a given country. Economic forces that can enable or starve a technology initiative are also largely driven by the non-military sectors of society, and their impact is partially encompassed in this chapter by inclusion of the defense industry as an indicator. The primary input for MTI from an economic system, however, is in the monetary funding allocated for innovation and related projects, and this aspect of economic influence has already been addressed in the context of organizational factors.

The contextual variables are briefly introduced below. Their complexity and the degree to which they overlap with other variables already covered in this study will vary widely with the countries and technologies being examined. A more exhaustive treatment of these variables falls beyond the scope of this project.

Industry

A nation's science and technology infrastructure is a critical to its innovation effort and is in most countries led by private or semi-private industry. Ahmed Hashim asserts that an advanced RMA infrastructure is a prerequisite for the RMA perceived to be under way. "RMA Militaries have to function within a society that is techno literate."[4] He also shows how the size of the defense industrial base correlates with the national potential for innovation, using Japan as an

example.[5]   The industrial sector naturally serves as a major contributor to technological development, as previously discussed in the technology chapter. Furthermore, industry can often be modeled as a lobby or interest group, active and powerful in the organizational forces that direct MTI. Beyond these, however, there may exist special or unique relationships between an industry and military, and the politics of defense production and R&D inevitably have repercussions for technologies outside the intended sector. There may exist a sizable cross-flow of manpower from the military into certain industries, and the other connections between society, industry and the military that may occur in certain nations cannot be overlooked for significant impact on innovation.

Academia

Universities represent a significant resource of brainpower and materiel for the R&D critical to MTI. The relationships that exist between higher learning institutions and the military can also result in enhancements or detriments to innovation, and as such warrant investigation. The next item that should be considered is an informed debate on the technology's utility and concepts for employment. Valid indicators of this process, essential for an innovation to take hold, gain national support and maintain momentum, include debate developed in scholarly or professional journals and/or in professional conferences and in congressional/parliamentary testimony.[6]

Media

The media as an elite element in society seems to acquire increasing political clout as the means to channel information between parts of society become more efficient and numerous. The media serves as a primary information link between most of society at large and the armed forces, and even more so in nations whose militaries lack developed public relations staffs.

Insofar as the media retain a sense of identity with their own charter to present their version of the truth, and the decisive potential of military innovation remains dependent to some degree on perspective, secrecy, and surprise, the media maintains the capacity to significantly influence military innovation both in its host nation and abroad.

Civil-military relations

The field of civil-military relations is vast and rich with variety, and with some tools that can add to an assessment of a military's readiness to innovate, or its maturity in some aspects of maturation. Among the facets of civil-military relations commonly studied, the status of the military profession in a society can offer clues to the support an army can expect from a civilian sector in terms of personnel, resources, and political influence.[7] The military's status as an institution is routinely compared with that of other institutions in a variety of polls and surveys, some of which are international, such as the Eurobarometer. These offer valuable trend data for determining the sociological role of a nation's armed forces and citizens' careers in the military, beyond military's fundamental mission to defend its citizens and territory. These trends can provide insights with significant implications for MTI.

Notes

[1] Niccolo Machiavelli, *The Prince*, in *Winning the Next War*, by Stephen Peter Rosen, (Ithaca: Cornell University Press, 1991), 1.

[2] Stephen Peter Rosen, *Winning the Next War*, (Ithaca: Cornell University Press, 1991), 9-19.

[3] Stephen Peter Rosen, *Winning the Next War*, (Ithaca: Cornell University Press, 1991), 254.

[4] Ahmed S. Hashim, "The Revolution in Military Affairs Outside the West," in *Journal of International Affairs,* Vol. 51, Issue 2 (Spring '98): 432.

[5] Ahmed S. Hashim, "The Revolution in Military Affairs Outside the West," in *Journal of International Affairs,* Vol. 51, Issue 2 (Spring '98): 434.

[6] Ahmed S. Hashim, "The Revolution in Military Affairs Outside the West," in *Journal of International Affairs,* Vol. 51, Issue 2 (Spring '98): 431-440.

[7] Ahmed S. Hashim, "The Revolution in Military Affairs Outside the West," in *Journal of International Affairs,* Vol. 51, Issue 2 (Spring '98): 435.

Chapter 7

Conclusion

Prejudice against innovation is a typical characteristic of an Officer Corps which has grown up in a well-tried and proven system.

—Field Marshal Erwin Rommel

The result of the research herein described is a framework to approach the comparative study of armed forces between nations, be they belligerent or allied, or neither. The framework is a comprehensive array of variables, deliberately selected, defined, and organized to completely and accurately indicate a measure of military technical innovation. While Karl von Clausewitz played down the importance of technological innovation in *Vom Krieg*,[1] which remains a powerful and relevant treatise on the nature of war, it is safe to conclude a greatly increased significance for innovation in weapons and their employment in the modern context. The importance attributed to technical innovation in modern militaries is evident in the pages of the vast majority of modern scholarly works on the subject, at least in the West. This body of literature, analysis, and theory makes clear the need for deep and dynamic understanding of technical innovation in the world's armies. At the same time it serves as the foundation for the variable indicators developed in this study, and which are listed in the summary below.

1. Possession of Technology
2. Production vs. Import: Means of Procurement
3. Technological Infrastructure
4. State of Technological Development
5. Versatility
6. Operational and Tactical Doctrine

7. Training
8. Operational Employment
9. Operational Readiness
10. National Innovation Strategy
11. Visionary Leadership
12. Organizational Elements for Innovation
13. Innovation Programs
14. Innovation Resources
15. Force Structure
16. Officer Cadre
17. Contingency Support Groups
18. Industry
19. Academia
20. The Media
21. Civil-Military Relations

The variables represent a listing of the processes, players, resources and relationships that must be included in any adequate assessment of a military's efforts to innovate with technology. They are defined to describe the concepts they seek to measure and propose general conceptual boundaries, but at the same time they are not so overly detailed as to restrict their applicability to the modern, industrialized and armed nations of the globe. As such, the analyst may choose to further subdivide these indicators with more refined variables, tailored to a specific technology, region or conflict. As they stand, they may be quantified in binary terms (i.e. conditions for the variable are either adequately met or not) or more rigorously developed to a weighted scale. With validation by factor analysis applied to enough historical cases, the scales could be combined in a single "innovation index" with powerful and far-reaching utility. This project and the resulting indicators lay the groundwork for further research along these lines.

Notes

[1] This observation is found repeated in most contemporary translations and interpretations of Clausewitz's work. See for example Irving B. Holley, Jr., *Ideas and Weapons*, (New York, Yale University Press, 1953), 11-12.

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